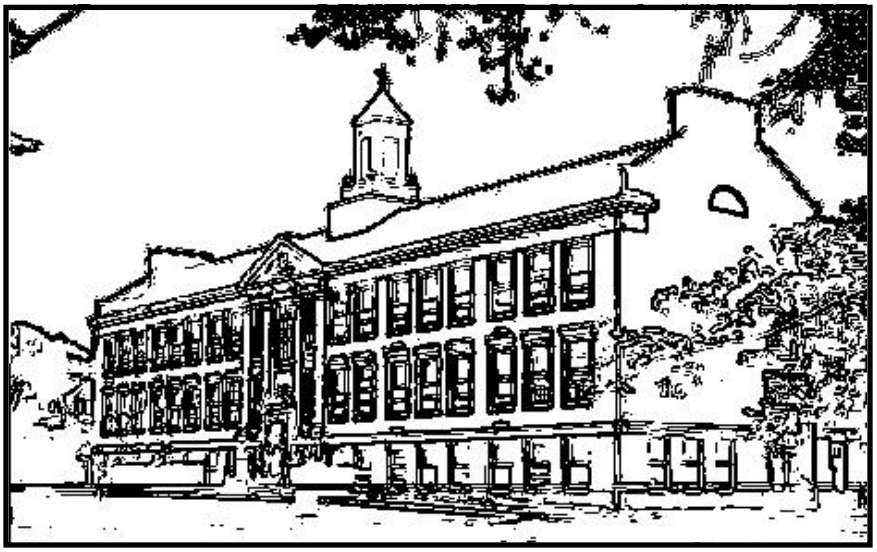
INDOOR AIR QUALITY REASSESSMENT

Nathaniel Morton Elementary School
6 Lincoln Street
Plymouth, Massachusetts



Prepared by:
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Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
May, 2001

Background/Introduction

At the request of Arthur Montrond, Supervisor, Buildings, Grounds & Maintenance, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Nathaniel Morton Elementary School (NMES) in Plymouth, Massachusetts.

The school was originally visited by Michael Feeney and Cory Holmes of BEHA's Emergency Response/ Indoor Air Quality (ER/IAQ) Program, on April 11, 2000 to conduct an indoor air assessment and a report was issued (MDPH, 2000). The report showed that there were problems identified and gave recommendations on how to correct those problems. On December 13, 2000 the school was re-visited by Mr. Feeney to conduct a follow-up indoor air quality assessment. Mr. Montrond accompanied Mr. Feeney during the assessment.

Actions on Previous Recommendations

BEHA had previously made 18 **short-term** and 4 **long-term** recommendations to improve indoor air quality. The purpose of the short-term recommendations was to provide school department officials with methods to help reduce reported indoor air quality-related symptoms within the school. The Plymouth School Department and NMES staff had implemented many of these recommendations at the time of the reassessment and should serve to improve indoor air quality in the building. The following is a status report of action(s) on BEHA recommendations based on reports from school officials, documents, photographs and BEHA staff observations.

Actions on **Short-Term** Recommendations

1. **Survey classrooms for univent function to ascertain if an adequate air supply exists for each room and make univent repairs as needed. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.**

   Univents were reportedly examined and repaired in each room over the previous summer. All univents were operating in classrooms during the reassessment. The Plymouth School Department has hired an HVAC engineering firm to balance the school's heating and ventilation systems.

2. **To maximize air exchange, the BEHA recommends that mechanical ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.**

   All univents reportedly now operate continuously during school hours.

3. **Consider increasing univent filter efficiency. Note that increased filtration can reduce airflow produced through increased resistance. Prior to any increase of filtration, univents should be evaluated by a ventilation engineer to determine whether they can maintain function with more efficient filters.**

   Filter efficiency was not examined during this reassessment.

4. **Remove all blockages from univents to ensure adequate airflow.**

Staff were instructed by the school department to remove materials obstructing airflow of univents. Adherence to this advice was apparent school-wide.

5. **Ensure abandoned natural/gravity feed exhaust and supply vents are properly sealed to eliminate pathways for movement of particulates into occupied areas.**

   All abandoned natural/gravity feed exhaust and supply vents were sealed with plywood (see Picture 1).

6. **For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).**

   Custodial staff have increased wet mopping and wiping to improve dust control. In addition, vacuum cleaners with special filtration have been purchased.

7. **Move plants away from univents in classrooms. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.**

Staff were instructed by the school department to examine plants and drip pans for mold growth periodically and to remove from the air stream of univents. Adherence to this advice was apparent school-wide.

8. **Repair/replace broken windowpanes in classroom 35.**

   Windows were repaired.

9. **Install weather-stripping around exterior doors to prevent water intrusion.**

   Doors were weather- stripped.

10. **Ensure aquariums and terrariums are properly cleaned to prevent odors and/or algae growth.**

    Aquariums and terrariums were found cleaned and well maintained.

11. **Store food items properly to avoid spoilage and associated odors.**

    Food items were removed from classrooms.

12. **Determine if sink in the art room is operable. If not in use, seal drain or pour water down regularly to prevent sewer gas back up.**

    No sewer odors were noted in the art room by BEHA staff.

13. **Change filters for univents as per the manufacturer's instructions, or more frequently if needed. Clean and vacuum interior of univents prior to operation to avoid the re-aerosolization of accumulated dirt, dust and debris.**

    School officials reported that interiors of univents were cleaned and vacuumed. Debris from inside univents was removed. Filters are now changed as per the manufacturer's instructions.

14. **Ensure local exhaust ventilation in teachers' room is operating during photocopying and lamination activities to remove excess heat and odors. Consider reducing or discontinuing use of the mimeograph machine.**

Staff were instructed by the school department to activate local exhaust fan while conducting photocopying.

15. **Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.**

Chalkboard trays appeared to be free of excess chalk dust.

16. **Encapsulate damaged pipe insulation in classroom 28 and in the second floor boys' restroom to avoid the aerosolization of fiberglass fibers. Seal ends of fiberglass pipe insulation.**

Damaged fiberglass insulation was repaired.

17. **Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.**

The school department is working on alternate storage space for teachers to reduce classroom clutter. As mentioned previously, wet mopping and wiping procedures have been implemented to improve dust control.

18. **Install weather-stripping around the edges of the attic access way to render airtight.**

Weather-stripping was installed around the attic access way.

Actions On **long-term** Recommendations

Long term recommendations made in the previous report require planning and consultation with a number of consultants, which can include architects, ventilation engineers and construction consultants. These recommendations are likely to require extensive renovations to the school and warrant funding, planning and execution over the course of several years.

1. **Examine the feasibility of providing mechanical exhaust ventilation building wide. Contact an HVAC engineering firm to determine if existing airshafts, vents, ductwork, etc. can be retrofitted for mechanical ventilation.**

   The school department has hired a consultant to examine the feasibility of installing a modern mechanical ventilation system in the school.

2. **Examine the feasibility of installing mechanical fresh air supply ventilation in the 1913 building classrooms and basement classrooms. Consider consulting a ventilation engineer concerning the feasibility of repairing or replacing univents that are original equipment in classrooms.**

   See above

3. **Repair roof/window leaks and replace/repair any water-stained ceiling tiles and wall plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial if necessary.**

   Leaks have been fixed and walls and ceilings with water damage have been repaired.

4. **Identify the purpose of the wall coating exterior brick of 1913 building. Consider having exterior brickwork repointed and waterproofed to prevent further water intrusion.**

   BEHA staff did not obtain any information concerning actions on this recommendation.

In addition to these recommendations, school officials have repaired damaged downspouts (see Picture 2) to ensure proper drainage.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor Model 8551.

Results

The school has a student population of approximately 600 and a staff of approximately 65. The tests were taken during normal operations at the school. Test results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in eighteen of forty-two surveyed, which is an improvement compared to the previous report. Fresh air is currently supplied in many classrooms by a

unit ventilator (univent) system (see Figure 1). As stated previously, univents were functioning in all classrooms surveyed. No means of mechanical supply ventilation exists in the 1913 building; therefore these areas continue to utilize openable windows to introduce fresh air into classrooms.

Classrooms throughout the building are equipped with large cast iron radiators beneath windows. This radiator configuration in combination with openable windows can be used in the winter to introduce fresh air. The radiators create a column of heated air that rises towards the ceiling. The design of the radiator system allows for cold fresh air from cracked windows to temper the heated air produced by radiators. Since the exhaust ventilation system is abandoned due to structural concerns, the use of exterior windows can supplement univents to introduce fresh air into classrooms, thereby diluting environmental pollutants (e.g., humidity, carbon dioxide) that can commonly build-up and lead to comfort complaints. Please note that the use of openable windows in the building can have several detriments. Windows left open after hours during colder months can create issues concerning security and the possibility of freezing pipes that can occur during reduced heating system operation.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993, SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings were within a range of 69^{o} F to 78 ^{o}F, which are very close to the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o}F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is difficult in an old building without a functioning ventilation system.

The relative humidity was measured in a range of 13 to 20 percent, which was below the BEHA recommended comfort range in all areas sampled. The BEHA

recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Conclusions/Recommendations

The Plymouth School Department, working in conjunction with NMES staff has improved overall indoor air quality at the school by implementing many of the BEHA's previous recommendations. In view of the findings at the time of the visit, in addition to those made in the previous report, the following recommendations are made to further improve indoor air quality:

1. Examine appropriate methods for using openable windows to supplement fresh air supply in the building.
2. Continue to implement recommendations made in the previous assessment.
3. Continue with plans to examine options for implementing long-term recommendations for restoration/installation of the ventilation system in the school.

References

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

MDPH. 2000. Indoor Air Quality Assessment Nathaniel Morton Elementary School, Plymouth, MA. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA. June, 2000.

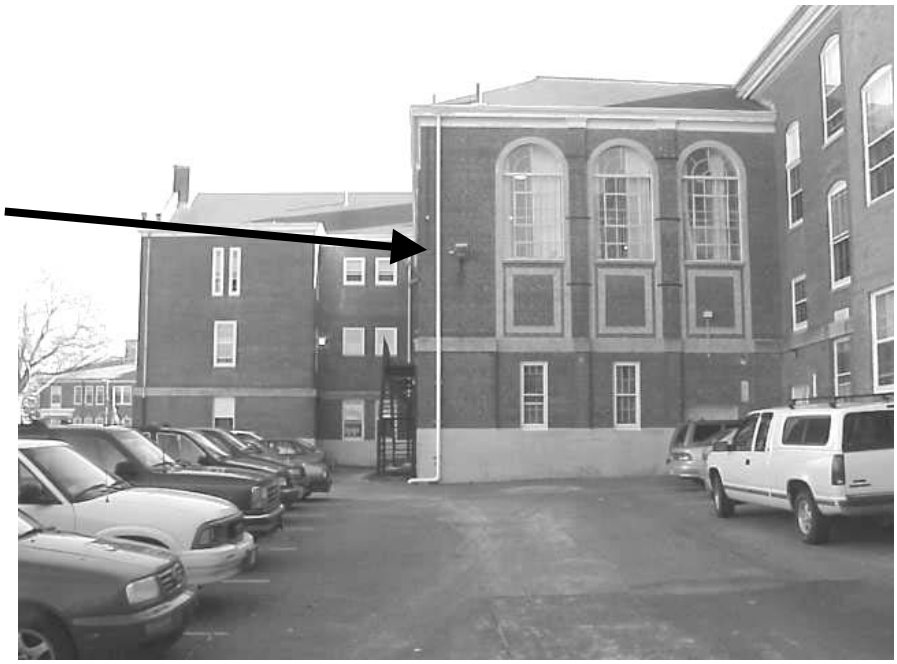
OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Picture 1

Sealed Exhaust Vent

Picture 2



Newly Installed Rain Downspout

TABLE 1

Indoor Air Test Results Nathaniel Morton Elementary School, Plymouth, MA – December 13, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	388	<32	22					
302	1019	77	18	28	Yes	Yes		Window and door open, supply off
303A	673	77	16	5	Yes	Yes		Window and door open
303B	751	76	16	0	Yes	Yes		Exhaust sealed with plywood
304	802	76	16	20	Yes	Yes		Window and door open, exhaust sealed with plywood
305	785	76	16	20	Yes	Yes		Exhaust sealed with plywood, window and door open
30	656	77	14	0	Yes	Yes		Exhaust sealed with plywood, window and door open
31	830	76	6	15	Yes	Yes		Exhaust sealed with plywood, window and door open
32	941	76	17	20	Yes	Yes		Exhaust sealed with plywood, window and door open
33	984	75	18	22	Yes	Yes		Exhaust sealed with plywood, 1 missing CT, door open
34	561	77	15	1	Yes	Yes		Exhaust sealed with plywood, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems
Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 2

Indoor Air Test Results Nathaniel Morton Elementary School, Plymouth, MA – December 13, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
34A – Speech Room	920	76	16	4	Yes	No	No	
35	1156	73	19	16	Yes	No		Supply and Exhaust sealed with plywood, door open
36	1292	73	70	21	Yes			Supply and exhaust sealed with plywood, door open, dry erase board
36A	1318	73	20	6	Yes	No	No	Door open
37	917	74	19	0	Yes			Supply and exhaust sealed with plywood, door open
38	836	72	17	0	Yes			Supply and exhaust sealed with plywood, door open
39	714	74	16	15	Yes	Yes		Exhaust sealed with plywood, door open
301	700	78	16	0	Yes	Yes		Exhaust sealed with plywood, door open
201	533	78	15	2	Yes	Yes		Exhaust sealed with plywood, door open
Gymnasium	640	77	14	25	Yes	Yes		Exhaust sealed with plywood
29	611	76	14	5	Yes	Yes		Exhaust sealed with plywood

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Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 3

Indoor Air Test Results Nathaniel Morton Elementary School, Plymouth, MA – December 13, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
28	680	72	16	0	Yes	Yes		Exhaust sealed with plywood, window open
26	1171	72	19	23	Yes			Supply and Exhaust sealed with plywood, door open
25	838	69	18	0	Yes			Supply and exhaust sealed with plywood
24	885	73	19	20	Yes	Yes		Exhaust sealed with plywood, door open
23	621	75	15	16	Yes	Yes		Exhaust sealed with plywood, window and door open
22	658	73	18	20	Yes	Yes		Exhaust sealed with plywood, window and door open
21-Music Room	929	76	17	16	Yes	Yes		Exhaust sealed with plywood, door open
205	819	75	16	23	Yes	Yes		Exhaust sealed with plywood, door open
204	619	75	15	5	Yes	Yes		Exhaust sealed with plywood, door open
Office	616	78	16	1	Yes	Yes		Exhaust sealed with plywood, door open
203	473	73	13	0	Yes	Yes		Exhaust sealed with plywood, door open

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CT = ceiling tiles

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Carbon Dioxide - < 600 ppm = preferred
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Temperature - 70 - 78 °F
Relative Humidity - 40 - 60%

TABLE 4

Indoor Air Test Results Nathaniel Morton Elementary School, Plymouth, MA – December 13, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
202	793	74	17	19	Yes	Yes		Supply off, Exhaust sealed with plywood, door open
101	729	75	18	0	Yes	Yes		Exhaust sealed with plywood, door open
Cafeteria	765	76	16	150+	Yes	Yes	Yes	Door open
Art Room	1660	74	20	17	Yes	No	No	
Teachers' Room	936	74	17	7	Yes	No	No	Door open
105	560	75	15	0	Yes	Yes		Exhaust sealed with plywood, door open
104	508	75	14	2	Yes	Yes		Exhaust sealed with plywood, window and door open
103	442	75	13	0	Yes	Yes		Exhaust sealed with plywood, door open
102	754	75	19	0	Yes	Yes		Exhaust sealed with plywood
101	622	75	18	1	Yes			Supply and exhaust sealed with plywood

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Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%